E&A

MAY, 1921

IMP. BUR.
23 JAN. 1922
ENTOM.

BULLETIN 242

THE GREEN JUNE BEETLE

OR

FIG EATER

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NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION

CONDUCTED JOINTLY BY THE STATE DEPARTMENT
OF AGRICULTURE AND THE NORTH CAROLINA STATE
COLLEGE OF AGRICULTURE AND ENGINEERING

RALEIGH

THE GREEN JUNE BEETLE, OR FIG EATER[1]

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Entomological Assistants, Cereal and Forage Insect Investigations

INTRODUCTION

The green June beetle (*Cotinis nitida L.*),[2] or fig eater, as it is sometimes termed, is one of the most common and conspicuous insects of the South, and numerous inquiries relative to it or to the immature form, the grub, are received annually. It is hardly likely that the grub is directly responsible for killing grass, as is quite generally supposed, and this feature will be fully discussed in a following paragraph. Indirectly the grubs have been responsible for considerable injury to field crops, such as alfalfa as well as to golf greens—injuries which made necessary the investigations herewith reported. The adults, the velvety green June beetles, frequently attack fruit, especially figs, grapes, and peaches, and occasionally injury to other crops, such as corn, is reported.

Our studies on the common white grubs (*Lachnosterna spp.*), have naturally led to a study of related genera, particular reference being made to the habits and work of the larvæ and means of distinguishing one from the other. Although our common white grubs are by far the most important from the economic viewpoint, it is nevertheless of greatest importance that farmers and others, as well as entomologists, be able to recognize readily the related species in the larval or grub stage, whether they be directly or indirectly injurious or simply scavengers. This publication not only treats of the economic status of the grub of the green June beetle, but gives also simple characters for the identification of the related species likely to be confused. Our investigations on the life history and habits of this insect were made at Columbia, S. C., by the junior author, and at Louisville, Ky., and Lafayette, Ind., by the senior author.[3]

INJURY

The adult beetles are frequently reported injuring fruits of various kinds, including figs, peaches, grapes, plums, apricots, prunes, nectarines, pears, apples, raspberries, and blackberries. Of these, the thin-skinned fruits, especially figs, peaches and grapes, are most often damaged, the other fruits listed above being only occasionally or slightly attacked. Injury to figs in South Carolina, Georgia, and other Southern

[1]This bulletin is of interest to farmers, gardeners, and others in North Carolina and other Southern States. Published with the approval of Dr. L. O. Howard, Chief, Bureau of Entomology, Washington, D. C.

[2]More commonly known under the name *Allorhina nitida.*

[3]This opportunity is taken to acknowledge the assistance of Mr. A. F. Satterthwait of this office in the care of breeding cages during the spring of 1913.

States is an annual occurrence, and indeed one of the popular names of this beetle, fig eater, originated from its prevalent habit of feeding on this fruit. From Pennsylvania southward comes the frequent report of injury to peaches, very often to those which are quite sound, contrary to the opinion of some authors that only decaying, partially decayed, or overripe fruit is attacked. The green June beetle is likewise a well-known grape pest, and Prof. H. Garman reports injuries to this fruit in Kentucky as follows: "The common green June bug, well known to every Kentucky schoolboy, becomes very troublesome locally, and occasionally by cutting the skins of grapes and utterly destroying the fruit of whole bunches and even whole vines. On the experiment farm at Lexington this pest would, if allowed to work unhindered, destroy the whole crop of the early varieties in the experimental vineyard. It was formerly more troublesome than now, but is liable any season to appear in such numbers as to be the cause of anxiety on the part of those having the vineyard in charge. The very sweet, thin-skinned, early sorts suffer most severely. On a visit to the vineyard August 1, 1896, I found Moore's Early, Poughkeepsie, and White Imperial being severely damaged, while Brilliant was only moderately injured. The clumsy beetles were clinging to the berries, in some cases a dozen on a bunch, greedily devouring the pulp and leaving them in an unsightly and utterly ruined condition. They were guilty of injury to early peaches and plums during the same month." (Garman, 1904.)

Besides the orchard fruits, Webster and Mally report injury to tomatoes by these beetles in southern Ohio (Webster and Mally, 1897), and even such fruits as melons are sometimes eaten. Corn in the ear is a favorite food of the beetles, which not infrequently are sufficiently numerous to injure noticeably both field and sweet corn. They have even been observed injuring young corn plants by gnawing into the stalk, and in one instance young sorghum plants were attacked.

Their fondness for sweets sometimes tempts the beetles to enter beehives, thereby causing more or less disturbance.

Three unusual feeding habits have been previously reported. Mr. Charles W. Long observed the beetles attacking walnut trees and described the injury as follows: "They appeared to bite through the bark, making a hole one-eighth inch wide and one-half to three-fourths inch long. The bark seemed to be softened with some exudation from the mouth." (Leng, 1884.) In 1888 Mr. W. W. Meech, of Vineland, N. J., found beetles feeding greedily on the fungus *Roestilia aurantiaea* on quince trees (Riley and Howard, 1888), and in 1891 Mr. Frank Triplett observed them boring into and extracting sap from tender branches of black oaks at Springfield, Mo., the injury causing the leaves to wither and the branches to dry and break off. In the latter case the attack seemed to be confined to the tops of the trees. (Riley and Howard, 1891.)

The beetles are sometimes a nuisance in well-kept lawns and golf greens, due to the little mounds of earth excavated by them as they enter the ground.

The grubs have been considered serious enemies of lawns and garden crops for years, although the most recent authorities have rejected this view. From the facts that we have gathered, the grubs may damage crops under unusual conditions, but most of the injury reported is either indirect or grubs of the genus Lachnosterna, our common and most destructive white grubs, were associated, and doubtless they and not the Cotinis grubs were responsible for the direct injury; or, noticing the grubs in conspicuous numbers, injury may only have been anticipated by the observer. It is unquestionable that these grubs prefer soil heavily fertilized with animal manures; and, further, that they may and usually do live and mature in manure or similar decomposing matter. Prof. H. Garman concludes that "it is now known that they (grubs of *Cotinis nitida*) feed only on dead vegetable matter, manure, compost and the like, and are consequently most numerous where food of this sort is most abundant, viz., about heavily enriched land, and in the vicinity of old heaps of decaying manure." (Garman, 1904.) We are able to corroborate Garman's statement that these grubs may live and complete their transformation in soil completely devoid of any living vegetation. Dr. Howard (1879) called attention to the fresh and green condition of the lawns at the Capitol grounds in Washington in spite of the fact that grubs occurred in enormous numbers in the ground. The same author (1898), in the most complete article on this species published prior to the present one, says: "The actual amount of damage done by these larvæ is problematical, and in fact it is even problematical whether they normally do damage at all." And again, "Taking all these considerations together, it is probably safe to say that the normal food of the Allorhina larva is the vegetable mold of rich soils, and that in its larval stage it is not a crop pest." And again, "In view of the well-known habits of the . . . Cetonians, all of the species of which, whose habits are known, being feeders upon decaying vegetation only, it seems strange that the root-feeding hypothesis should ever have been adopted. Probably the basis of such an hypothesis was the great abundance of the larvæ in the soil and their resemblance to Lachnosterna larvæ."

Instances where the grubs of the green June beetle were directly injurious are few. Fruit lying on the ground, or such crops as celery, endive, etc., which are covered for bleaching and afford excellent conditions for the grubs, may be directly attacked and damaged, especially if the grubs are abundant. On the other hand, reports of injury to such crops as grass, strawberries, corn, alfalfa, etc., by the eating of the roots, are probably incorrect; at any rate we have never been able to verify such reports.

Indirectly the grubs may considerably damage garden and field crops as well as lawns and meadows by their tunneling and burrowing, up-

rooting young, tender plants, as well as causing the ground to become porous to such an extent that evaporation increases and the plants thereby suffer from lack of moisture.

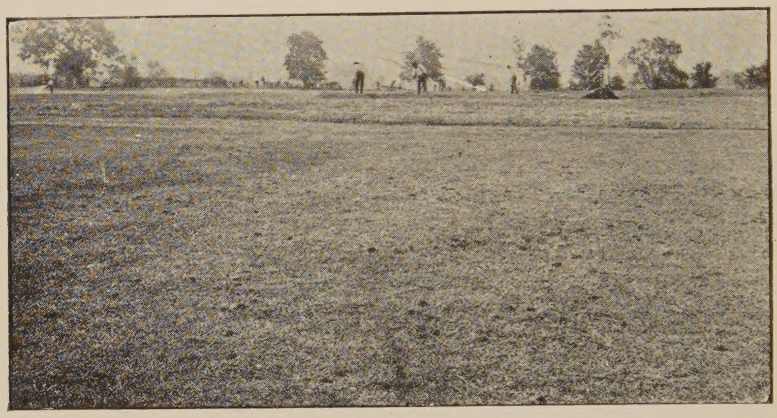

FIG. 1—Mounds of earth thrown up by grubs of *Cotinis nitida*. Photograph made at Louisville, Ky. (*Original.*)

Lawns are sometimes disfigured and made unsightly by the tunneling of the grubs and by hills of earth thrown up. (Fig. 1.) In this case the trouble is analogous to infestation of ants in lawns. Likewise in such well-kept grass plats as golf greens the grubs become extremely troublesome, and especially on the putting greens, which should be thoroughly clothed with grass and perfectly smooth, the mounds of earth not only mar the beauty of the green, but also hinder the players.

INDIVIDUAL OFFICE RECORDS OF INJURY

INJURY BY THE BEETLE

On August 10, 1909, at Salisbury, N. C., Mr. R. A. Vickery, of this bureau, found the beetles feeding on the kernels of corn near the tip of the ear, the injury having been started by another and closely related beetle, *Euphoria sepulchralis* Fab.

At Wellington, Kans., E. O. G. Kelly and T. H. Parks observed the beetles feeding on young cornstalks, July 19, 1909. They were feeding near the base of the stalk, where they bored large holes, usually between the second and third joints of the cornstalk. Mr. Kelly repeated this observation on July 22 and 28, and later (August 10) he found them feeding on the corn kernels at the tip of the ear.

July 14, 1911, Mr. G. G. Ainslie found the beetles feeding on the kernels of sweet corn at Nashville, Tenn.

Mr. W. H. Larrimer, also of this bureau, reported injury to sorghum at Nashville, Tenn., in 1913. On July 21 he observed the beetles in the

"throat" of the sorghum plants, the supposition being that they had been attracted there by the honeydew of the corn leafaphis (*Aphis maidis* Fitch) or possibly by the sweet sap of the sorghum itself. The beetles caused the leaves to split at the base, thereby injuring the plants to quite an extent. When the field was revisited, July 28, not a beetle could be found, and while the plants were attempting to outgrow the injury the damaged ones were easily distinguished.

The junior author found the beetles common among colonies of *Aphis maidis* on sorghum, during August, 1914, at Columbia, S. C. They did not in any way injure the plants and were feeding only on the honeydew secreted by the plant lice.

INJURY BY THE GRUBS

Mr. Parks found the grubs abundant in a lawn at Haverford, Pa., on September 23, 1910, but no damage was observed other than the fact that they threw up small mounds of earth, a characteristic habit of the grub.

Under date of October 9, 1912, James Kenny & Co., of Riverside, N. J., wrote to this department relative to this grub as follows: "It is cutting the lawn around here every night and also cuts the roots of geraniums and other flowers." No further proof of injury has been received from this source.

Another correspondent in New Jersey wrote this office under date of September 19, 1913, that these grubs were very abundant in his lawn at Elberon, their presence being evidenced by the throwing up of a hillock of soil which was not unlike an ant hill. He stated that the lawn was being ruined by these grubs, but the information available does not show that the grubs fed on the grass roots.

Mr. E. B. Cantrell, of Winston-Salem, N. C., reports under date of January 11, 1913, that these grubs were very abundant in his garden; so much so as to interfere with the growth of the plants. The two years previous Mr. Cantrell used stable manure freely on his garden and, as he surmised, this was doubtless responsible for the appearance of the grubs in such numbers. Writing again, under date of March 18, Mr. Cantrell says: "I have observed the grubs for a number of years and have never known them to occur on any kind of land or injure any kind of crops excepting where stable or lot manure has been used. Therefore their greatest numbers are to be found in gardens. The grubs breed and thrive on manure and most any crops planted there. Especially in dry weather there is damage by them as they plow up and make holes that cause plants to suffer for moisture. Sometimes plants are cut off, tomatoes on the ground eaten, and especially have they injured my celery."

At Hot Springs, Va., the grubs proved very troublesome on the golf links, and Mr. W. T. Bingham wrote us September 25, 1913, that "this

grub destroys the roots of bluegrass and also bothers the golfers considerably by the mounds of earth thrown up. The ravages of the grubs are said to be so extensive in some parts of the surrounding country that farmers in some instances have been forced to abandon their pastures." Further information is not at hand, and it is not improbable that the grubs responsible for the killing of the grass were those of *Lachnosterna,* although it is known that *Cotinis* grubs were abundant there.

On October 24, 1914, Mr. C. F. Turner found the grubs doing considerable damage in the gardens belonging to Mr. L. G. Buckner at Memphis, Tenn. Corn, potatoes, turnips, and eggplant were among the crops said to be attacked. The grubs received from Mr. Turner proved to be those of the green June beetle. In reply to our request for further information, Mr. Buckner writes under date of November 5, 1914, as follows: "The grubs in our garden keep the ground near the surface pulverized. A rain of course packs the ground and in a day or two the ground is again pulverized. We are not sure that the plants died because the roots were eaten or whether it was the continuous working under and around them. They did not bother the plants on top of the ground. We had a very fine patch of turnips, and they killed nearly all of them. They also ruined tomato vines and English peas. They attacked fall potatoes (Irish), not killing the vines, but I know they ate some of the potatoes; however, not a great deal. Our garden has been well fertilized with stable manure."

Mr. S. M. Arthur, of Republican Grove, Va., reported on October 6, 1914, injury to alfalfa by grubs of this species. From less than a half acre of ground in alfalfa he caught 2,121 grubs in one night, and 577 another night. Dr. Henry Fox, of this bureau, investigated the supposed injury and reports that the grubs did not directly attack the plant, but the injury resulted from their burrowing. About one acre, which had been rather heavily manured, was sown to alfalfa in August. At night, especially after a rain, the grubs worked their way to the surface and collected under pieces of manure, and in their movement upward uprooted and exposed the roots of the young alfalfa plants. Their burrowing likewise made the soil porous and spongy, a condition that accelerates evaporation, which had a damaging effect on the plants. Injury was confined entirely to the young plants, those with even a moderately developed root system not being injured. No evidence was found that the grubs actually gnawed the roots.

More recently (October 28, 1914) Prof. James Troop, entomologist at Purdue Experiment Station, has shown us grubs of this species which he received from a correspondent at Bedford, Ind., who reported that they were damaging endive. The correspondent wrote under date of October 27, 1914, as follows: "The endive I had covered with a board to bleach. Frequently when I would lift a board off of the endive I would see the worm disappearing in the hole out of which his head had been protruding, and quite often they would in this manner eat a third

and often half of the bunch of endives." From a previous letter it seems the writer had adopted two methods for bleaching the endive—one by laying boards over the plants and one by bunching and tying up the heads—but that the grubs attacked only that under the boards.

Mr. A. H. Beyer, of this bureau, investigated an oat field at Columbia, S. C., which had been noticeably damaged by this grub. Along one edge of the field the oat plants were dead, but in no case had the roots been eaten, injury resulting from a loosening of the soil about the plants by the grubs, thereby partially uprooting the plants as well as causing the soil to dry out.

Our own experience with the grub of the green June beetle has been primarily at Louisville, Ky. Injuries to the golf greens of the Louisville Country Club were reported to this department in 1912, and the senior author was instructed to investigate the injury. We found that the grubs were not directly injurious to the grass, but that they worked in the putting greens every night, throwing up little hills of earth, and these, if not swept off early in the morning, would be trampled on by the players, thus packing a thin layer of earth solidly over the surrounding grass, which resulted in killing the grass in this particular spot, and the green, which should be perfectly smooth, would be roughened. At no time did we observe the grubs feeding on the roots of the grass nor have we seen any evidence of injury to grass other than the indirect injury noted above. The entire golf links was plowed and seeded in 1909, and the first occurrence of the beetles in noticeable numbers was in 1911. Every year the ground is heavily fertilized by means of animal fertilizers, principally sheep manure.

Grub injury to lettuce grown out of doors and in greenhouses was reported to us in 1919 by Mr. O. G. Willits of the Campbell Soup Company farm at Riverton, N. J. We were advised that injury occurred in the fall and that lettuce was apparently cut off and pulled partly into the grub furrow. The soil was very rich in animal manure, which seems to account for the great abundance of grubs, and it seems likely the soil was infested previous to being placed in the greenhouses. Mr. Willits finds it practical to steam sterilize the soil in the forcing and greenhouse beds and his method of sterilization is described in a following paragraph.

In breeding cages the grubs cut off the young stalks of wheat, rye, cotton, and sorghum plants as well as paspalum grass (*Paspalum dilatatum*), but they did not molest other grasses or corn when grown in the cages. It is quite possible, if not probable, that the cutting off of these plants was accidental, since the grubs were very active and completely tunneled the soil in the pots.

DISTRIBUTION

The insect under discussion is generally distributed east of the Mississippi River and south of latitude 29 degrees, that is, as far north as St.

Louis and Cincinnati in the Mississippi and Ohio valleys, and somewhat farther north along the Atlantic Coast. The farthest-north record was made by Mr. F. C. Bowditch (Psyche, v. 7, June, 1896, Supp. 2, p. 8), who collected it from the summit of Mount Washington.

LIFE HISTORY AND HABITS

The life history may be briefly summarized as follows: The large, robust green beetles appear in July and August, and because of their rapid, noisy flight, as well as by their bright green color, they are quite conspicuous. Once they alight, the humming, which considerably resembles that of the bumblebees, entirely ceases; and if they alight in the grass they are well protected from the casual observer, for their color closely harmonizes with the color of the grass. It is in the adult stage that they are most destructive, the beetles attacking fruits of various kinds, more especially grapes, figs, peaches, plums, etc., as well as corn in the ear.

After mating, the female deposits her quota of eggs in the soil, and these hatch ordinarily in two or three weeks. All of our observations show that the female lays her eggs perferably in soil which has been heavily manured. Upon hatching, the grubs tunnel through the soil, feeding on humus, and they have a peculiar habit of running their burrows to the surface of the ground from the open exit of which they throw out little piles of earth resembling ant hills. This work seems to be done only at night, at which time the grub may even leave the burrow entirely and crawl over the surface of the ground, this habit being especially noticeable on warm, wet evenings. The grubs continue to feed and grow until cold weather sets in, by which time they are at least two-thirds grown. During the colder periods they remain inactive at the bottom of their burrows, which at that time of the year may be as much as two feet below the surface. They do not become completely dormant as do the common white grubs of the Northern States, at least not south of latitude 38.5 degrees, for at Louisville, Ky., we have known them to become active during the milder days of winter, even in the months of January and February. Active feeding begins as soon as spring opens up, but by June they complete their growth, after having molted twice, and prepare brittle earthen cells, within which they pupate, the first beetles emerging about the last of June or the first of July. Thus it will be seen that the total life cycle of this insect, that is, from the time the eggs are laid until the mature beetle issues, is just one year.

HABITS OF THE ADULT

The beetles make their first appearance above ground the first week of July in the latitude of Louisville, Ky., and as early as the last week in June at Columbia, S. C., the exact date depending on weather conditions. They gradually become more abundant until about the 20th to

the 30th of July (August 10 at Columbia), after which date their numbers diminish, or at least they become less noticeable to the casual observer. The beetles are usually to be seen until the end of the first week in August at Louisville, or the first of September in the latitude of Columbia, and in our breeding cages at Lafayette the last beetles, which in all cases were females, died August 27. On the other hand, at Columbia the last caged beetle died September 30 in 1913, and October 15 in 1914, in the latter case the last beetle being a male.

During the periods of abundance the beetles appear about daybreak, the females appearing first, or at least they are relatively more abundant than the males early in the morning, from daybreak until after sunrise.[1] Shortly after sunrise the females begin to settle in the grass, often first searching for the exit of a burrow or starting a fresh hole, and then resting on the ground amongst the grass preparatory to mating. By this time the male beetles predominate, and they become relatively more abundant as the morning advances and the females gradually become less numerous. By 7 a.m. (later on cloudy days) the males are exceedingly numerous, buzzing here and there in search of females. In heavily infested localities the air near the ground becomes "alive" with the beetles, which rapidly fly back and forth, buzzing incessantly, all of which gives one the impression of a clover field full of bumblebees. They usually fly 6 to 12 or 18 inches above the ground, but often higher.

From our observation it appears quite certain that the male is attractd to the female by the rather strong and sickening odor of a milky fluid secreted by the latter, for he usually drops to the ground within a few inches of a female and, searching through the grass, seems to have no difficulty finding her within a minute or two. Male beetles will alight near a female even when the latter is completely hidden from view.

From 8.30 to 11 a.m. the number of beetles gradually diminishes, and after that comparatively few are to be found flying. By 1 p.m., and throughout the afternoon, only an occasional bettle is observed flying about. On one of the days when observations were made it rained most of the morning until 10.45, after which the sun came out and the beetles appeared in numbers. At Columbia, S. C., the junior author found the beetles most active between 11 a.m. and 3 p.m., it being quite difficult to capture them at this time, and even when found feeding they took flight at the least disturbance. Evidently most of the beetles spend the night in the soil or under debris of one kind or another, but we occasionally found male beetles at night resting in shubbery, quite inactive and not feeding, nor were they attracted to the electric flash light which we carried.

On entering the ground the beetle throws up a little mound of earth which is not unlike that made by the grub and described later. The mound resembles a small ant hill, differing from the latter in that the

[1]The following field observations were made at Louisville, Ky., except as noted.

particles of earth are coarser. More often the males, after their daily flight or after they have mated, burrow just beneath the grass or loose sod, and in the case of the putting greens of a golf course, which are kept perfectly smooth and the grass closely clipped, small mounds, resembling miniature mole burrows, indicate the presence of a resting beetle beneath. The female beetles, after mating go deeper into the soil, that is, from 2 to 4 or 5 inches, where they lay the eggs for the next brood.

Our observations indicate that the beetles also use their sense of smell in their search for food. For instance, an overripe fig was placed in a breeding cage containing a number of beetles which had not been fed for several days. Immediately one beetle about 6 inches distant from the fig began to move its head about as though scenting the pleasing odor, then to encircle the fruit, and shortly thereafter moved directly toward it and began to feed. In another cage beetles refused to touch ripe figs which were free from bruises or other imperfections, although they immediately attacked and fed on these same fruits after the skin was cut. This does not prove that the beetles will not attack perfect ripe fruit, but tends to show that they are not attracted to figs until the odor is delectable—in other words, until the fruit is bruised. Being attracted to fig trees by the odor of bruised fruits, it is possible that the beetles will, when very abundant, attack even uninjured figs, although we have not observed the beetles feeding on fruits which have not been previously bruised or injured.

THE EGG

The eggs are usually laid in the soil from 2 to 5 inches beneath the surface.[1] When first laid they are pearly white, symmetrically elliptical, and measure 1.5 mm. in width to 2.1+ mm. in length. As the embryo within develops they become almost spherical, measuring 2.5 to 2.8+ mm. in width and 2.8 to 3.1+ mm. in length, and 24 to 48 hours before hatching the embryonic grub is plainly visible through the eggshell. The eggs are remarkably elastic, usually rebounding without injury to the embryonic larva within when dropped on a hard surface, and in this respect they differ materially from the eggs of our common brown May beetles (*Lachnosterna spp.*), which usually burst when dropped or placed on an absorbing surface such as a blotter. Although resembling the eggs of the common brown May beetles, they are larger than those of most May beetles and methods of oviposition in the two are decidedly different, the eggs of the latter being laid in individual balls of earth while those of the green June beetles are in larger earthen balls, a number of the eggs being laid in each ball. The balls of earth vary in size from that of a medium-sized hickory nut to the size of a large walnut, and the number of eggs in each ball varies from 10 to 30, one lump,

[1] In flowerpot cages containing fine sifted soil the eggs are laid as deep as 8 inches, and in one instance an egg was found 12 inches below the surface in loose soil out of doors.

which was no larger than a walnut, containing 27 eggs. Evidently all of the eggs in each ball of earth are laid at one continuous period of oviposition and, as in the case of *Lachnosterna,* a glutinous secretion holds the ball of earth intact. Although the eggs are not laid in individual balls of earth, they are laid in individual cells within the large ball.

A single beetle probably lays as many as from 60 to 75 eggs under normal conditions. In two of our breeding cages, individual females laid 52 and 83 eggs, respectively, in both cases more than four-fifths of the total number being laid prior to July 22, and in the case of the former the female was removed from the cage before she was through egg-laying. In another cage, in which 23 females were confined, 756 eggs were laid, an average of 32.8+ eggs per beetle, and of those 690 were laid between July 14 and 21, and the remaining 66 between July 21 and August 4. In still another cage 33 females laid 768 eggs, or an individual average of 23.3 eggs, and 551 of these were laid between July 14 and 22, and 217 between the latter date and August 2. On the other hand, the 1913 records at Columbia showed a somewhat greater egg capacity. In one cage containing 1 female and 2 males, 90 eggs were laid, all during the first two weeks of August, and in another cage containing 3 females and 3 males an average of 65 eggs per female was deposited, and in this case the majority were laid during the first half of August, a few, however, as late as September 1. In a 1914 cage, containing 2 females and several males, 198 eggs were laid, an average of 99 per female, and the period of oviposition lasted from August 4 to October 1, and although the majority were laid the first two weeks of August, one-third were deposited during September. Two beetles examined at Louisville, Ky., July 16, contained 54 and 76 fully developed eggs, respectively. Examinations of other specimens collected at Louisville July 14 and 16 gave the following egg counts: 6 beetles collected July 14 contained 54, 68, 55, 65, 61 and 45, respectively, and 5 beetles collected July 16 contained 46, 52, 59, 45 and 58 eggs, respectively. All eggs were fully developed, not a single undeveloped egg being noticed.

The period of oviposition extends through the months of July and August, but our observations show that the female lays the majority of her eggs from July 10 to 25 in the latitude of Lafayette, and from July 25 to August 15 at Columbia, S. C.

The length of the egg period varies, according to our breeding cage records at Lafayette, from 15 to 18+ days, as will be seen in Table I. The eggs were kept in closed tin boxes in cool, shaded places and in what were considered approximately natural conditions. At Columbia the average length of the egg stage was 18.5 days in 1913 and 23 days in 1914, the difference possibly being due to differences in temperature

(Table II). The egg receptables used in the later experiments were shallow pots, known to the dealers as fern pots, covered with saucers.[1]

It is noteworthy that although the beetles appear as early in the latitude of South Carolina as in Kentucky, the period of maximum oviposition is later and beetles are active for a much longer time in the former locality than in the latter.

TABLE I. *Records of egg period of the green June beetle Lafayette, Ind., 1913*

Date eggs were laid	Date of hatching	Number of eggs	Length of egg stage
			Days
July 16 to 21	Aug. 2	20	12 to 17
	Aug. 3	30	13 to 18
	Aug. 4	6	14 to 19
	Aug. 6	1	16 to 21
July 23	Aug. 7	23	15
July 16 to 22	Aug. 5	7	14 to 20
	Aug. 6	42	15 to 21
	Aug. 7	18	16 to 22
	Aug. 8	5	17 to 23
	Aug. 9	3	18 to 24
	Aug. 10	1	19 to 25
July 23	Aug. 7	15	15
July 24	Aug. 8	26	15
	Aug. 9	22	16
	Aug. 10	8	17
	Aug. 11	2	18
Aug. 8 to 18	Sept. 1	16	14 to 24
July 18 to 22	Aug. 4	24	13 to 17

TABLE II. *Record of egg period of the green June beetle Columbia, S. C., 1913-14*

Date eggs were laid	Date of hatching	Number of eggs	Length of egg stage
1913			Days
July 28 to Aug. 1	Aug. 19	53	18 to 22
Aug. 9 to 11	Aug. 25	53	14 to 16
Aug. 5 to 7	Aug. 20 to 23	81	13 to 18
Aug. 28 to Sept. 1	Sept. 13 to 20	6	12 to 23
1914			
Aug. 24 to 26	Sept. 8	3	13 to 15
Aug. 26 to 31	Sept. 14 to 15	20	14 to 20
Aug. 30 to Sept. 4	Sept. 24	21	20 to 25
Sept. 4 to 7	Oct. 1 to 8	11	24 to 34
Sept. 4 to 8	Oct. 5	5	27 to 31
Sept. 8 to 11	Oct. 10	6	29 to 32
Sept. 16 to 21	Oct. 13	3	22 to 27

[1]In our work at Lafayette the tin boxes have given the most uniform results, although the opposite is the experience of the junior author in his experiments with Cotinis at Columbia. This difference seems likely due to variation in humidity.

HABITS OF THE GRUBS

When the embryonic larva is ready to hatch it causes the egg to split transversely at a point where the head and anal end of the larva, within the egg, touch. Immediately upon freeing itself from the eggshell it becomes quite active, crawling on its back, as do the older grubs, when placed on the surface of the soil. In one instance a recently hatched grub crawled 6½ inches in 35 seconds, and another one crawled 2½ inches in 10 seconds, or at the rate of 15 inches a minute, and nearly mature individuals travel over 2 feet in one minute.[1]

The grubs grow very rapidly, feeding on animal manure and similar decomposing matter, and their presence becomes more conspicuous daily. They are most noticeable in the late fall, and it is at this time that complaints are more frequent.

The first grubs hatch the first of August, and often by the middle of that month they become noticeable in lawns and gardens. At this time numerous young grubs will be found in the same area, as though they worked in colonies, and this would be expected, since a number of eggs are laid close together. Later the larvæ scatter, and infestation of the lawn or garden becomes more or less uniform.

The grubs have distinct open burrows which average 6 to 12 inches in depth, although late in the fall they may reach a depth of a foot and a half, and the surface hole is about the size of one's thumb. The burrows usually go almost straight down, although there may be lateral burrows, and during the day the grub is likely to be found at the bottom. At night dirt is thrown out at the exit of their burrows, the little mounds of earth thus appearing being from 2 to 3 inches in diameter and closely resembling ant hills, although the particles of earth are somewhat coarser, but not as coarse or pasty as is earth excavated by angleworms.

Often the grubs come out of their burrows at night and crawl over the surface, and especially is this true on warm, wet evenings. Their mode of locomotion is very peculiar and characteristic, for they crawl on their backs, being unable to do otherwise since their legs are short, apparently somewhat aborted, and unfit for use in walking or crawling. When placed on a smooth surface the grub turns over on its back, legs uppermost, and by alternate contraction and expansion of the body segments

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[1] In referring to the "June-bug (*Allorhina nitida*)," Mr. James Mooney (Myths of the Cherokee, 19th Annual Report Bur. Amer. Ethnology, 1897-98, p. 308) writes that the Cherokee Indians know it by the name *"tagu,* but [it] is frequently called by the curious name of *tu ya di skalaw, sti ski,* 'one who keeps fire under the beans.' Its larva is the Grubworm which presided at the meeting held by the insects to compass the destruction of the human race." The story of this supposed meeting is given on pages 250-252 and runs as follows: Owing to the increase in the numbers of the human race, the animals and plants, including the insects, found themselves cramped for room, and they decided to hold a meeting, over which the Grubworm presided. "They began to devise and name so many new diseases, one after another, that had not their invention at last failed them no one of the human race would have been able to survive. The Grubworm grew constantly more pleased as the name of each disease was called off, until at last they reached the end of the list, when someone proposed to make menstruation sometimes fatal to women. On this he rose up in his place and cried 'Wadan [Thanks] I'm glad some more of them will die for they are getting so thick that they tread on me.' The thought made him fairly shake with joy so that he fell over backward and could not get on his feet again, but had to wiggle off on his back as the Grubworm has done ever since."

moves very rapidly, usually in a very nearly straight line, the body undulating in wavelike motions, and sometimes, when it apparently becomes overbalanced, rocking from side to side. The corrugations on its back are furnished with transverse rows of short and stout bristles which are of considerable assistance for this mode of locomotion. So far as we have been able to observe, grubs of this genus and of Euphoria are the only American species which crawl exclusively on their backs.

The grub is able to reënter the soil quite rapidly, and to do this, being on its back, bends the head and fore part of the body backward and downward, and by use of head and feet begins its burrow.

Toward winter the grub usually deepens its burrow, and during the colder months remains inactive at the bottom, but it is quickly revived even during short periods of warm weather, and not infrequently continues its work on warm days. In fact, as far north as Louisville, Ky., we have known the grubs to be active during parts of the months of January and February.

As warm weather returns in the spring the grubs likewise make their normal reappearance, and after a short period of feeding becomes full grown and prepare their pupal cells a few inches to eight inches below the surface and within these, pupate. Pupation takes place the latter part of May or first of June.

THE PUPA

The cell within which the larva transforms to a pupa is quite distinctive and measures 0.75 to 0.8-inch wide and 1 to 1.15 inches long. The cell is constructed of earth glued together by a fluid secreted by the larva. The outer side is rough, but the inside is perfectly smooth, rendered so by its maker, the grub. On one side of the cell is a prominent hard protuberance, and this is brought out in the figures mentioned above. It would appear that debris and excrementitious matter is thrown out at this opening just before it is sealed and the cavity then filled, plastered and smoothed so that the whole inside of the cell is quite uniformly smooth. The walls of the cell are rather thin and are remarkably brittle. When crushed, which requires very little pressure, it crumples very much as does a bird egg. This distinctive pupal case seems to be characteristic for grubs of this and a closely related genus, for aside from the insect under discussion (Cotinis), we have found it only in the genus Euphoria; in fact the pupal cells of the two genera are identical except that the former are noticeably larger than those of Euphoria.

When it pupates the cast larval skin is pushed to one end of the cavity, and after remaining in the pupal condition some 16 or 18 days it transforms into the adult or beetle stage. Usually the beetle remains in the cell some days, estimated from various observations at 7 to 14 days, before leaving the cell and coming to the surface. In making its exit the beetle makes an irregular opening at one end of the earthen case.

DESCRIPTION

Larva or grub.—Recently hatched larvæ measure 0.6 inch (7 to 8 mm.) in length when outstretched, as in crawling about, and 0.15 inch (2 mm.) in width. They resemble the older larvæ in characters except that the hairs, especially the long hairs projecting posteriorly from the anal segment, are relatively longer in the young larvæ.

The full-grown larva measures 2 inches in length and nearly one-half inch in diameter, thicker at its posterior extremity. It is whitish or cream colored with a blackish brown head and with the antennæ, palpi, clypeus, legs, spiracles, and a subtriangular chitinous plate on each side of the prothoracic segment just in front of the spiracle of a paler brown. The head is comparatively small, flattened, somewhat wrinkled, and well inserted into the prothoracic segment. The mandibles are stout, as might be expected, for they are largely used in burrowing and the left (looking from the dorsum) is 4-dentate and the right 3-dentate. The atennæ are 4-segmented, the basal segment being longest, the others gradually diminishing in length and width. The maxillary palpi are 3-segmented and the labial palpi 2-segmented. The labrum is apparently 3-lobed at margin. The legs, which are very small for the size of the grub, bear numerous moderately long and spinelike hairs and serve to assist in throwing back the earth. The small but rather prominent spiracles are present on the prothoracic and first eight abdominal segments, those of the prothorax being only slightly larger than the abdominal spiracles. The ventral surface of the abdomen is somewhat flattened and the ridges well covered with rather long, silky, pale brown hairs, which are shorter on the anal segments. The dorsal surface is strongly transversely corrugated, each segment with three distinct ridges, and each ridge well covered with short, stiff, pale-brown hairs which are posteriorly directed and greatly assist the larva in its dorsal locomotion. The posterior end of the body is more or less slate colored, which is due to the food and excrement within the alimentary tract. The anal slit is transverse. The ventral surface of the nal segment is moderately thickly and uniformly clothed with short, pale-brown hairs, with a median double row of darker brown, stout, cone-shaped spines, 10 to 18 in a row.

The larva molts twice before transforming to the pupa, and the average head widths of the three instars are 1.7, 3.0, and 5.5 mm., respectively.

The larvæ are difficult to separate from those of *Cotinis mutabilis,* its nearest relative. However, the larvæ of *mutabilis,* which occurs only in the arid and semiarid Southwest, is larger when full grown, the mandibles of the two species are different, the spines of the two median longitudinal rows on the underside of the anal segment are stouter and more conspicuous, and the rows themselves are a little father apart; also the hairs covering the under surface of the anal segment are longer than in *nitida* and the spines on the legs coarser.

From our common white grubs (*Lachnosterna spp.*) this grub is readily distinguished by its dorsal locomotion, somewhat larger size when full grown, shorter legs and relatively smaller head, by the transverse anal slit, which in Lachnosterna is angular, and absence of hooked hairs on the ventral surface of the anal segment.

The grubs of another related species (*Cyclocephala sp.*) differ by lacking the two median rows of spines on the ventral surface of the anal segment, as well as by using their legs in walking instead of crawling on their back.

Grubs of the flower beetles (*Euphoria fulgida* Fab et spp.) closely resemble the Cotinis grubs, in that they crawl on their backs, but are distinguished by their smaller size when full grown, and the under surface of the anal segment is not uniformly clothed with hairs, the remainder of the ventral surface being bare; furthermore, spines in the two median longitudinal rows are directed or inclined inwardly and are not so thick or stout as in Cotinis.

The larva of *Ligyrus gibbosus* DeG. et spp., known as muck worms, are readily distinguished in that they lack the two median longitudinal rows of spines on the underside of the anal segment.

The larvæ of two other related species (*Cotalpa lanigera* L. and *Dyscinetus trachypygus* Burm.) are likewise distinguished by lacking these rows of spines.

Pupa.—In general shape the pupa resembles the adult beetle, and when first formed is pure white, soon changing to light brownish, afterwards gradually darkening, and shortly before emergence taking on some of the metallic green and brownish tints of the adult. It is shorter than the grub, measuring 0.95 inch to 1.05 inches (24 to 26 mm.) in length, averaging 1 inch, and through the thoracic region, where the body is widest, the width is 0.5 to 0.55 inch (13 to 14.5 mm.). The width of the abdomen at its widest point is 0.4 to 0.475 inch (10 to 12 mm.), and it gradually lessens posteriorily, the anal segment being only 0.2 to 0.25 inch (5 to 6 mm.) across. At the tip of the last abdominal segment, protruding rather conspicuously from the dorsum just above the anal opening, are two thick liplike prominences, one on either side, and divided by a narrow impressed line. On the underside of this same segment, and just below the anal opening are three fleshy spherical protuberances, placed together in a triangular form.

Adult.—The mature beetle is elongate-oblong, measuring a little less than an inch (19 to 23 mm.) in length, and at the widest point, at the base of the wing-covers or elytra, it is approximately one-half inch (11 to 13.2 mm.). The entire dorsum is velvety green, with the side of the thorax and elytra brownish yellow. Occasionally this latter coloration is slight, while often it is more prominent than above described. The head is metallic green and the under surface of body shining greenish brown, usually the brownish tints predominating. The femora are light brown with a slight greenish tint when held at certain angles,

and the tibiae and tarsi are concolorous with the underside of the body. The head is deeply sculptured, there being a longitudinal cavity on each side of the median line and an elevated ridge on the outer side of each cavity, as well as a prominent central horizontal blunt spine or protuberance which extends forward nearly to the upturned protuberance of the clypeus. The pronotum is triangular, narrowing markedly toward the front, which is truncate, and its posterior end pointed and covering the scutellum. The elytra taper gradually posteriorily, the tips being truncate, beyond which the rounded end of the abdomen is visible.

The *Cotinis* of the Southwest (*C. mutabilis*) is similar to the species under discussion, but the distribution of the former is confined to the Southwestern States, and this fact alone makes confusion of the two unlikely. *Mutabilis* is a much larger species, is of a more uniform velvety green, and ordinarily it lacks the brownish yellow margin on the thorax. The blunt spine or protuberance on the clypeus is more prominent and above all the coloration of the under surface of the body is quite different, for it is uniformly metallic green, excepting the abdomen, which is a rich, deep reddish brown when held at certain angles. The femora are uniformly metallic green, instead of pale brown as is the case with *nitida*.

Another species, *Euphoria fulgida*, is likely to be confused with *nitida*, and also its distribution is similar. However, its life history is different in that the beetles appear in September, pass the winter in the adult stage and reappear in spring, at which time the eggs are laid. By the time the beetles of *nitida* appear, those of *E. fulgida* have disappeared. The two species are readily distinguished, *fulgida* being shining metallic green above, smaller in size, lacking the sculpturing on the head and bearing two rows of white transverse markings on each side of the under surface of the abdomen; also the scutellum is not covered by the pronotum and is plainly visible.

NATURAL ENEMIES

A black and orange banded digger wasp (*Scolia dubia* Say) (Fig. 2) is a common parasite of grubs of the green June beetle in some localities and materially assists in the control of that pest. However, we have never found it capable of completely holding the insect in check, which may be accounted for by the fact that *Cotinis* appears to be its only host. The chocolate colored cocoon (Figs. 3 and 4), resembling that of the white grub parasite *Elis*, except that it is larger and has a more parchment-like surface, is to be found in the fall, winter or spring about 6 to 10 inches below the surface. The insect passes the winter as a larva within the cocoon, pupating in spring, and the adult wasp issues about the middle of August, about the time the young grubs become conspicuous. During their active season the wasps may be observed flying back and forth, rather near the ground, over grub infested areas. Occa-

FIG. 2—Adult Wasp parasite, *Scolia dubia*. Photographed at Lafayette, Ind. (*Original.*)

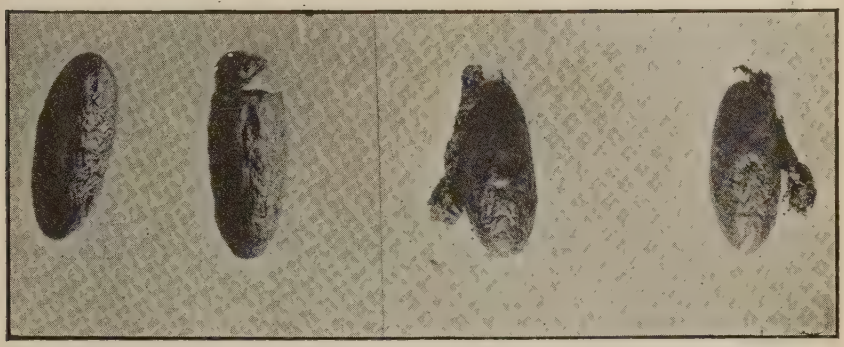
sionally one will alight and search for a grub opening in the soil. On finding a grub burrow the wasp will enter and remain for a period of 5 or 10 minutes. If dug up, the grub will usually be found paralyzed and lying on its back at the bottom of the burrow and a cream colored egg attached to the under side of the body. The grub when paralyzed by this wasp never comes back to life, in which respect it agrees with the common white grub parasite *Elis*. The egg, which is approximately 1 mm. wide and 3 mm. long, is quite characteristically placed, being attached on end usually between the fourth and fifth abdominal segments, and agrees in this particular with a related species (*Campsomeris dorsata*), which is a parasite of *Ligyrus tumulosis* in Barbados, West Indies.[1] Upon hatching the young larva feeds on the paralyzed grub until full grown when it makes the cocoon in which it remains until the following year. In exceptional cases the adult wasp may not issue until the second summer.

Three sarcophagid flies were reared from *Cotinis nitida* by Mr. D. E. Fink, of the Truck Crop Insect Investigations, at Norfolk, Va., in 1914. Two species, *Sarcophaga sarraceniae* Riley (Aldrich det.) and *S. helicis* Towns. (Walton det.) were reared from adult Cotinis and another *Sarcophaga utilis* Aldrich (Aldrich, 1915) was reared from partially formed pupæ. Mr. Chas. T. Greene of this Bureau, bred three specimens of *S. helicis* (Aldrich det.), August 17, 1912, from dead Cotinis adults, in which case it was unquestionably a scavenger. We have reared *S. utilis* from dead *Cotinis* adults, in which cases it was almost certainly

[1]Nowell, W. Two Scoliid parasites on scarabaeid larvæ in Barbados. *In* Annals of Applied Biology, v. 2, No. 1, pp. 149-158, 1 pl., May, 1915.

a scavenger (Davis, 1919). These and other data indicate a possible question as to the parasitic habits of the above mentioned sarcophagids.

In a published discussion of a paper on *Cotinis mutabilis* by Dr. C. H. T. Townsend, Mr. W. B. Alwood (Alwood, 1891) states that he had reared a dipterous parasite from the adult *C. nitida,* but the species was unknown.



Figs. 3 and 4.—Cocoons of the parasite *Scolia dubia,* one cocoon showing typical exit opening made by adult wasp. Remains of grub still adhere to cocoons shown in Fig. 4. Photographed at Lafayette, Ind. (*Original.*)

Mites are often found attached to Cotinis adults, but there is no evidence that they are predaceous. Mr. Harry B. Weiss (Weiss, 1915) records *Macrocheles marginatus* a species of mite, as occurring on *C. nitida.*

In our cages the grubs were readily attacked by the green muscadine fungus (*Metarrhizium anisopliae*), but it has never proved successful in our experiments out of doors under natural conditions.

Cotinis grubs are also attacked by a bacterial disease (*Micrococcus nigro-fasciens*) according to Miss Zae Northrup (Northrup, 1914). There is no evidence however that it plays any significant role in the control of the grubs.

Birds are among the most useful destroyers of the green June beetle. In 1891 Mr. Frank Triplett, in a letter to this department (Riley and Howard, 1891) reported the blue jay (*Cyanocitta cristata*) as feeding on the beetles, although from his observation other birds did not molest them. In 1910 a gardener at Haverford, Pa., reported to Mr. T. H. Parks, at that time connected with the Cereal and Forage Insect Investigations, that the grubs of the green June beetle often appeared on the surface of the ground in the evening and that the woodpeckers liked to visit infested ground at those times, which is rather satisfactory evidence that the birds were there to feed on the exposed grubs. At the Audubon Club golf grounds, Louisville, Ky., the foreman informed us that birds, especially the robin (*Planesticus migratorius*) were quite numerous in the mornings on the greens showing greatest infestation of grubs and beetles, indicating the fact that they were there to feed on the insects.

At the Louisville Country Club golf grounds where the grubs were also abundant, we observed the crow (*Corvus brachyrhynchos*), crow blackbird (*Quiscalus quiscula*) searching for the grubs, and it might be interesting here to note that a small flock of ducks, allowed access to a section of the grounds, eagerly sought the grub, sometimes thrusting their bills into grub burrows several inches. The ducks, of course, were able to gather only those grubs on or near the surface. Mr. W. T. Bingham, Hot Springs, Va., reported to the Washington office that he had observed the yellow-hammer (*Colaptes auratus*) and robin searching about in the golf grounds for these grubs, dragging them out of their burrows and devouring them. At Riverton, New Jersey, Mr. C. W. Leister found a nearly whole Cotinis adult in the crop of a sparrow hawk (*Falso sparverius*).

The Biological Survey has found the remains of *Cotinis nitida*, either adults or larvæ, in stomachs of the following birds: Broad-winged hawk (*Buteo platypterus*), pileated woodpecker (*Phloeotomus pileatus*), red-headed woodpecker (*Melanerpes erythrocephalus*), night-hawk (*Chordeiles virginianus*), kingbird (*Tyrannus tyrannus*), crow (*Corvus brachyrhynchos*), blue jay (*Cyanocitta cristata*), red-winged blackbird (*Agelaius phoeniceus*), crow blackbird (*Quiscalus quiscula*), cardinal (*Cardinalis cardinalis*), shrike (*Lanius ludovicianus*), brown thrasher (*Toxostoma rufum*), and wood thrush (*Hylocichla mustelina*). The insect was found in no fewer than 75 stomachs of the crow blackbird, and in several cases to the number of 7 or 8 to a stomach.

Mammals are likewise important enemies of the grubs. Moles are quite fond of them, as has been previously reported. In 1912 the opossum eagerly sought the Cotinis grubs at the Audubon Club golf links. Chipmunks were observed feeding on these grubs by Mr. W. T. Bingham at Hot Springs, Va., and our own observations indicate that skunks search for and eat the grubs.

METHODS OF CONTROL

IN LAWNS AND GOLF GREENS

Kerosene emulsion.—Kerosene emulsion has been repeatedly recommended against this and other white grubs, but evidently very few experiments have been made to affirm or disprove its value. In 1888 Mr. W. B. Alwood tested kerosene emulsion on the white grub of the green June beetle at Washington, D. C., on the Capitol grounds, with apparent success. However, his statements (Alwood, 1888) are contradictory to the life history of the species under discussion, and it therefore appears likely that other grubs were present and confused his conclusions. He made an application of kerosene emulsion June 1 and again June 8. No dead grubs were noticed up to June 27, although some were "weak and almost inactive," a fair description of larvæ in the prepupal stage. He further reports that on July 27 and 31 no living grubs

could be found on the treated areas, although they were plentiful on untreated sod. Since only beetles, eggs, and possibly a few recently hatched grubs of Cotinis would be found on these later dates, it is conclusive that some other species was confused. Our own experiments show that an 8 to 10 per cent kerosene emulsion is quite effective in

Fig. 5—Spraying greens with kerosene emulsion to destroy grubs. A large sprinkling-can nozzle is used. Photograph made at Louisville, Ky. (*Original.*)

destroying the white grubs of the green June beetle on golf greens, when applied at the rate of about 1 gallon to 6 or 8 square feet and afterwards thoroughly washed into the soil by copious sprinkling with water. At the Louisville Country Club golf grounds, Louisville, Ky., where the tests were made 80 per cent of the grubs in the treated area were killed by a single application. Some of the grubs came to the surface, but the majority died in the soil. Applications should be made as soon as the grubs become conspicuous, usually about the middle of August. Treatments made during late fall and winter are not to be depended upon as the grubs are deeper in the soil and less affected by any treatment. For small areas an ordinary sprinkling can may be used in applying the emulsion, but for larger areas the use of a force pump will save time and labor, using a wide sprinkling-can type of nozzle or "rose" so that the lawn can be uniformly drenched in the shortest possible time. (Figs. 5 and 6.) For larger areas a street sprinkler can be employed to advantage. Immediately after the application of the emulsion, the treated area should be thoroughly sprinkled with water in order to wash the emulsion from the foliage, which otherwise may be burned, and also in order to convey the insecticide into the soil.

Kerosene emulsion is prepared as follows: One-half pound of hard or one quart of soft soap, preferably fish-oil, rosin-soda, or rosin-potash soap, is dissolved in one gallon of boiling water, and while hot two gallons of kerosene are added and the mixture thoroughly emulsified.

This may be done most easily and thoroughly by churning for about ten minutes with a spray-pump, the nozzle being turned back into the liquid. When thoroughly emulsified it will have the consistency of thick cream, and the oil will not separate out. There is great danger of injuring plants if the mixture is not well and thoroughly made. For an

FIG. 6—Portable outfit used in spraying grub-infested areas on Louisville Country Club golf grounds. Photograph made at Louisville, Ky. (*Original.*)

8 per cent emulsion add 24 gallons of water to the above stock solution and thoroughly mix. It is desirable to use soft water both for the stock solution and as diluent, but where this is not obtainable the water should be softened by adding lye or sal-soda. A more easily emulsified and more penetrating, but slightly more expensive mixture can be made as follows: 4½ pounds of whaleoil soap is dissolved in 3 quarts of hot soft water, to which is added one quart of fusel oil and 2 gallons of kerosene and the whole thoroughly churned as in the preparation already mentioned. For an 8 per cent mixture add 24 gallons of water to the 3 gallons of stock solution and thoroughly emulsify.

On "putting greens" where the grass is very tender, kerosene emulsion may cause injury, and for these areas carbon bisulphid and hand-picking are recommended.

Other liquid soil insecticides.—Emulsifiable coal tar preparations which are essentially composed of coal tar oils, phenols, and a saponifying agent have given very good results against this grub, slightly less effective than kerosene emulsion, but as cheap and much more easily prepared since they readily mix with water. The results of the application of the coal tar products are more evident since a larger per cent of the grubs come to the surface (Fig. 7) before succumbing to the action of the insecticide. We find the insecticide appreciably more effective if an additional light sprinkling of it is made after the grubs come to the surface. A material analyzing approximately, phenols, 12 per cent; coal tar oils, 53 per cent; water, 10 per cent; saponifying agent, 25 per

cent, should be diluted one part to 125 parts of water and applications and subsequent sprinkling with water should be made as in the use of kerosene emulsion.

FIG. 7—Grubs come to surface and there die after an application of creosote or kerosene emulsion. Photograph made at Louisville, Ky. (*Original.*)

Carbon bisulphid.—Carbon bisulphid is a thoroughly reliable remedy and is especially useful on putting greens, but requires more labor than the insecticides already mentioned. Since the burrows of this grub are open they are easily reached by this chemical, the poisonous fumes of which are heavier than air, and the burrows can easily be located by the mounds of earth thrown up by the grubs during the night following a heavy sprinkling the evening before. The infested areas can be treated with reasonable rapidity with two men working together, one to expose the opening with an iron rod, the other to inject the liquid bisulphid by means of a large oil can and to stop up the opening with soil. (Fig. 8.) Approximately one teaspoonful of the liquid per burrow gives satisfactory results. Carbon bisulphid injures vegetation when applied directly to it and care in this respect must be used when handling. Care should also be exercised in the handling and use of this chemical, for it is inflammable, and the fumes, when mixed with air, explosive. There should be no fire of any kind near when handling the liquid.

Miscellaneous control measures.—Much can be done towards controlling the grubs by gathering them after a rain or after artificially flooding the infested ground. If the ground is flooded, the grubs appear at the exit of their burrows within a few minutes. As many as 3 quarts of the grubs have been picked from a single putting green after flooding with water in this manner.

Collecting beetles.—Collecting the beetles is a method which has been practiced in some localities, and while it is only partially effective, it is

a means which should be adopted wherever practicable. Various methods have been adopted in different places. At Louisville, Ky., the caddies were paid for collecting the beetles, the work being done in the morning. At Hot Springs, Va., boys were employed to collect the beetles at so much a quart. Here a trap was used, which was constructed as follows: "Wire netting was stretched on a frame 10 feet long and width of the roll (about 3 feet). This frame was set in a trough partly filled with water with a little kerosene on the top. The beetles would strike the netting and fall into the trough and the kerosene would finish them." The habits of the beetles would suggest the possible effective employment of a grasshopper-catcher, which is so practical in controlling grasshoppers. The time of collecting is of greatest importance, for the females appear at daybreak and begin to settle in the grass shortly after sunrise; hence, in order to destroy the females, collecting must begin early in the morning; also, collecting should start as soon as the beetles make their appearance in July, before they lay eggs, and should be continued throughout the month.

FIG. 8—Treating infested area with carbon bisulphid. Photograph made at Louisville, Kentucky. (*Original.*)

Effect of manuring.—There seems to be no doubt that beetles lay their eggs only in manure heaps or land which has been heavily fertilized with animal manure, and it is therefore recommended, in cases where injury is likely to occur, that chemical fertilizers be used in place of animal manures. The following formulas, which are complete fertilizers, have been suggested to take the place of applications of manure:

Formula No. 1

	Pounds
Nitrate of soda	100
Sulphate of ammonia	50
Sulphate of potash	100
Acid phosphate	250
Raw bone meal	1,000
Tobacco dust (ground tobacco stems)	500
	2,000

For lawns, apply early in spring at the rate of 500 to 1,000 pounds per acre:

Formula No. 2

	Pounds
Tobacco dust (ground tobacco stems)	1,000
Raw bone meal	1,000
	2,000

For lawns, apply early in spring at rate of 1,000 pounds per acre.

If humus is required to take the place of that which would be furnished in animal manure, peat soil can be applied.

In many cases no one method suggested above will be effective in thoroughly eradicating the grubs, and it may mean several years of thorough work. The use of commercial fertilizers in place of animal manures is probably the most important of the preventives. Wherever the grubs are present in the soil they should be killed by the use of one of the soil insecticides or carbon bisulphid, and this should be supplemented by hand-picking the grubs after flooding the infested land and by gathering the beetles.

Sweeping putting greens.—As has been stated the grubs may indirectly cause considerable trouble. On the putting greens the hills of earth are thrown up by the grubs during the night, and if allowed to remain they are stepped on by the players, thus resulting in a dead spot where the moist earth has been pressed on the grass. To prevent this injury boys may be employed to "sweep" the greens, and this can be quickly done by the use of long flexible bamboo poles as shown in the illustration. (Fig. 9.)

IN CULTIVATED FIELDS AND GARDENS

Preventive measures, such as avoiding use of animal manure the year the crop is sown, should be practiced for fall plantings of such crops as alfalfa, oats, etc., in areas liable to infestation. Of the direct remedies mentioned above the soil insecticides are the most practical ones, and the application should be made in early fall previous to planting, if possible. If practicable, hogs and farm poultry should be given the run of infested fields. They are fond of all kinds of grubs, and the hogs

will root to a considerable depth to get them. Plowing seems inapplicable in the case of this grub, except possibly in late May or June, when the grubs are in the prepupal stage or have recently pupated. The plowing should be deep, and when possible should be followed by thorough disking. Ground to be manured and fall cropped, which is fallow during the flight of the beetles, should be kept thoroughly cultivated to prevent, as far as possible, the beetles from ovipositing therein, and in any case the manure should not be applied until after the beetles have disappeared.

FIG. 9—Sweeping putting greens with long bamboo poles to scatter hills of earth thrown up by grubs each night. Photograph made at Louisville, Ky. (*Original.*)

IN THE ORCHARD AND VINEYARD

Gathering the beetles by hand is the only useful method of controlling this pest when it attacks such crops as grapes. Prof. H. Garman has briefly summarized control measures which come under this heading, as follows: "After a good deal of experimenting we find that this (hand-picking) is about the only method that will save crops from injury. It is a simple matter for a boy to pass along the plants with a bucket containing water bearing a film of coal oil on the surface, and knock the beetle into it. But it requires some watchfulness during the height of the beetle season, because others soon take the places of those removed. Baits of poisoned sirups have not proved as alluring as the ripe grapes, and but few beetles were poisoned by them. Sprays for either grapes or corn are impracticable." (Garman, 1904.)

IN GREENHOUSES

Frequently grubs are brought into greenhouses in the soil and become a nuisance and a pest. Soil for this purpose which is suspected or known to contain grubs should be sterilized by steam before it is taken into the house.

Mr. O. G. Willits, in charge of the Campbell Soup Company farms at Riverton, N. J., has found steam sterilization thoroughly effective in destroying the grubs of the green June beetle and considers this method not only practical for destroying insects and weed seed in the hot beds and greenhouse benches, but also helpful to the soil. His method is somewhat as follows: Iron pipes 1½ inch in diameter are used and are easily moved by the use of sleeve joints. The pipes have two rows of ⅛-inch holes one-inch apart. The pipes which are placed two feet apart are laid on a layer of soil, holes downward, and then covered with 6 or 8 inches of soil. The soil is then covered with a tarpaulin or canvas cover and 125 pounds of steam turned into the pipes. The steam is maintained for an hour, by which time the pressure has gradually gone down to about 60 pounds. The steam is effective for a distance of at least 6 or 8 inches below the lowest pipe and for a greater distance on either side.

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